SAFETY AND RELIABILITY REQUIREMENT OF ELECTRONIC SIGNALLING EQUIPMENT

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Abstract **This document defines Safety and Reliability Requirement of Electronic Signalling Equipment.**			

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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

INDIAN RAILWAY STANDARD SPECIFICATION FOR SAFETY AND RELIABILITY REQUIREMENT OF ELECTRONIC SIGNALLING EQUIPMENT

(DRAFT)

Serial No. RDSO/ SPN/ 144/2014

0.0 FOREWORD

0.1 This specification is issued under the fixed serial no. RDSO/ SPN/ 144 followed by the year of original adoption as standard or in the case of revision, the year of last revision.

0.2 This specification requires reference to the following Indian Railway Standards specifications (IRS), Indian Standards Specifications (IS), European Committee for Electrotechnical Standardization (CENELEC) and International Electrotechnical Commission(IEC)

(i) IRS: S 96 for DC-DC converters.

(ii) IRS: S 88 for Low maintenance Lead Acid Batteries.

(iii) IRS: S 93 for Valve Regulated Lead Acid Batteries.

(iv) IRS: S 86 for battery chargers.

(v) IS: 9000 for Basic Environmental Testing procedure for electronic and electrical items.

(vi) IS: 9001 Guidance for Environmental Testing.

(vii) IEC: 60034 for Degrees of protection.

(viii) IEC: 60947/7/1; terminal blocks for copper conductors.

(ix) IEC: 60571: Railway Applications-Electronic Equipment used on rolling stock

(x) IEC: 61643; Low-voltage surge protective devices

(xi) IEC: 62305; Protection against lightning

(xii) IEC:62236;Railway Applications-Electromagnetic compatibility (Part 1 to 5)

(xiii) IEC:62497;Railway Applications-Insulation Co-ordination (Part 1 to 2)

(xiv) IEC:62498;Railway Applications-Environmental conditions for equipments(part 1 to 3)

(xv) IEC:62278;Railway Applications-The Specification And Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

(xvi) IEC: 62279; Railway Applications-Communication, signalling and processing systems-Software for railway control and protection systems.

(xvii) IEC:62425;Railway Applications-Communication, signalling and processing systems-Safety related electronics systems for Signalling

(xviii) IEC:62280; Railway Applications-Communication, signalling and processing systems-Safety related communication(Part 1 and 2)

(xix) IEC:62427;Railway Applications-Compatibility between rolling stock and train detection system

(xx) IEC 61000;Testing and measurement techniques

(xxi) IEC:60255; Measuring relays and protection equipments

(xxii) IEC: 60352:5; Press-in connections – General requirements, test methods and practical guidance.

(xxiii) IEC: 60130; Connectors.

(xxiv) IEC- 61508: Standard for Functional Safety of Electrical/ Electronic/Programmable Electronic Safety Related Systems.

(xxv) EN 50126: Railway applications- specification and demonstration of reliability, availability, maintainability and safety.

(xxvi) EN 50128: Railway applications- signaling and communication-

Software for Railway control and protection system.

(xxvii) EN 50129: Railway applications- Safety related electronic systems for signaling.

(xxviii) EN 50159-1 & 2: Railway applications- Signaling and Communication Safety related communication in closed and open transmission system.

0.3 Whenever in this specification, any of the above mentioned specifications are referred to by number without mentioning the year of issue, the latest issue of that specification is implied, otherwise particular issue referred to is meant.

0.4 This specification is intended chiefly to cover only the technical provisions and does not include all the necessary provisions of a contract.

1.0 SCOPE

1.1 This specification covers the reliability and safety requirements of electronic (including microprocessor / micro-controller/ processor based) fail safe signalling equipments like Axle Counters, AFTCs, Electronic Interlocking Equipments, SSBPAC, UFSBI, TCAS, TPWS, IPS, DC-DC converters, LED signals, Power supply equipments, Telecom eqipments etc.

1.2 This specification shall be read with the main specification of the equipment.

1.3 Any special requirement, specified in the main specification of the equipment, shall override the requirements laid down in this specification.

2.0 GENERAL

2.1 The equipment shall be manufactured as per best engineering practices.

2.2 The cabinet shall be powder coated and shall have good aesthetic appearance. It shall conform to IP-31 class of protection as specified in IEC:60034.

2.3 The power portion of the equipment shall be clearly isolated and protected to prevent accidental contact.

2.4 All non-current carrying metals parts including shields and screens shall be bonded together and earthed. An earth terminal suitable for taking up to 4 mm diameter copper wire shall be provided. The earth terminal

shall be indicated by letter 'E'. Value of earth resistance shall not be more than 1 ohm unless otherwise specified.

2.5 Outsourcing, if any, of any sub-modules or PCB shall be indicated in the 'Quality Assurance Plan' and approval of RDSO, Lucknow shall be obtained. Outsourcing of safety related sub-modules or PCBs shall be from ISO-9001 or ISO-9002 certified manufacturers only.

2.6 Necessary provision shall be made in the hardware and software for modular expansion of the equipment.

2.7 Version Control:

2.7.1 For indigenous equipments, the version number of equipment shall be as per the format given below:

DXXSXXXHXX

DXX	**SXXX**	**HXX**
Basic Design	Software	Hardware
D: Design, S: Software, H: Hardware		
XX and XXX are numeric two and three digit numbers respectively.		
Thus the initial version of any equipment will be D01S001H01.		
In every case of modification/ upgradation/ improvement of Basic Design, DXX will increment by one.		
In every case of modification/ upgradation/ improvement of system Software (executive software), SXXX will increment by one.		
In every case of modification/ upgradation/ improvement of Hardware, HXX will increment by one.		

2.7.2 Version number shall be displayed on each PCB as per clause 6.11 of this specification. Similarly version number shall be displayed on the name plate of the equipment as per clause 12.4 of this specification.

2.7.3 The software version number shall appear on the LCD/LED display board immediately after power ON and shall be displayed for 10 seconds. The system shall display version number of the software for 10 seconds either by giving suitable command or by pressing a button.

2.7.4 Each document/ manual of the manufacturer shall contain the history of the changes in version along with accompanying changes in the manual, if any.

2.7.5 Signalling equipments which do not have any embedded software shall follow the following format for version number.

DXXHXX

DXX	HXX
Basic Design Change	Hardware Change
D: Design, H: Hardware XX are numeric two digit numbers.	
Thus the initial version of any equipment will be D01H01.	
In every case of modification/ upgradation/ improvement of Basic Design, DXX will increment by one.	
In every case of modification/ upgradation/ improvement of Hardware, HXX will increment by one.	

2.7.6 For equipments proposed under Cross Approval, the details of testing and display shall be indicated.

2.8 Change of system software

2.8.1 The system software shall be stored in separate PROM to ensure that the ROM is programmed only once and it is not be possible to modify the System Software. However, application engineers shall have the facility to modify application software as and when required. The application software shall be password protected and shall be accessed by authorized person only.

2.8.2 Any supply or installation of modified/ upgraded / improved system software by a firm for equipment shall only be done with prior approval of Signal Directorate of RDSO, Lucknow. While approving the upgraded/ modified/ improved software with new version number, RDSO shall verify the checksum of the system software as given by the manufacturer along with version number of the equipment.

2.8.3 The Director (Q.A.)/ S&T will check the version number and also the checksum of new version of the software before passing the same in the acceptance test.

2.8.4 Version number and checksum of new version shall form part of approval letter, acceptance and routine tests also.

2.8.5 After the acceptance test by Director (Q.A.)/ S&T, stickers with software version no. will be written with non erasable and visible marker pen on the PROMs. In case PROMS carrying new software version are to be supplied separately for replacing PROM's of already supplied equipment, these will be sealed in a proper package and stamped with RDSO's seal before the same are dispatched to the consignee for installation. The

version number and the checksum will be clearly typed or written on the sealed cover and signed by the inspecting authority.

2.8.6 Firms shall supply and install only the latest approved version of the equipment and software.

3.0 REQUIREMENTS OF SIGNAL ENGINEERING MANUAL

The equipment and its accessories shall comply with relevant Para of Signal Engineering Manual pertaining to signalling circuits using electronic equipment. The extract of relevant Para's is reproduced below:

3.1 Component failure shall be self-detecting by way of causing a signal to display a most restrictive aspect.

3.2 Failure of components which are not self-detecting shall not cause any unsafe failure of the equipment. Even simultaneous failures in different components which are not self-detecting shall not cause any unsafe failure of the equipment.

3.3 All fail-safe circuits shall work on continuous energisation principle such that open circuits in wiring, relay contacts, etc., or loss of power supply shall not cause unsafe conditions.

3.4 Common return shall not be used for vital circuits. In vital circuits, the final stage shall use fail-safe signalling relays. Isolation shall be provided between the final stage fail-safe signalling relay and the electronic device preceding it. The DC power supply shall not have any galvanic connection with the coil of the final stage signalling relay.

3.5 All electronic equipment shall have a Mean Time Between Failures (MTBF) as specified in the relevant equipment specification. Duplication of components and parts of equipment or modules may be resorted to for improvement of the reliability where necessary. Where components / parts modules are duplicated, it is desirable that provision may be made for cross checking the performance of one set by the other set and vice-versa.

3.6 Due consideration shall be given to the effects of faults in fail-safe electronic equipment to allow open or short circuit or earthing conditions and variation in component values due to ageing, replacement of faulty component with new components of specified tolerance, etc. Safety shall not be impaired as a result of multi-terminal devices failing - either open circuit, short circuit or with partial short circuit between any pair of terminals or earthing.

3.7 Special care shall be taken in the design of amplifier circuit to eliminate the possibility of self-oscillation. It is desirable that loss of safety requirements is not caused, should the amplifier go into self-oscillation due to any unforeseen contingency.

3.8 Where specific frequencies are used for safety circuits, particular care shall be taken to ensure that the frequency generating equipment is producing only the desired frequency signal. Verification shall be carried out using passive tuned filters in series with each frequency source.

3.9 The physical construction of fail-safe equipment shall be designed to eliminate the possibility of external objects causing short circuits between combinations of terminals in vital circuits. This may be achieved, for example, by adequate separation of terminals and by the fitting of protective shrouds, where necessary.

3.10 For the consideration of the fail-safe feature of an electronic safety signalling device, failure of one component for all the modes of probable faults indicated in paragraph 3.6, one at a time shall be considered. If the failure of the component under examination is not self-detecting, then simultaneous failure of other associated components shall be considered.

4.0 FAIL-SAFETY REQUIREMENT

4.1 The system should generally satisfy requirements of EN 50126: Railway applications- specification and demonstration of reliability, availability, maintainability and safety, EN 50128: Railway applications- signaling and communication- Software for Railway control and protection system, EN 50129: Railway applications- Safety related electronic systems

for signaling, EN 50159: Railway applications- Signaling and Communication Safety related communication in closed and open transmission system, IEC 61508 : Standard for Functional Safety of Electrical/ Electronic/Programmable Electronic Safety Related Systems & IEC: 62278: The Specification And Demonstration of Reliability, Availability, Maintainability and Safety (RAMS), IEC:62279: Communication, signalling and processing systems-Software for railway control and protection systems, IEC:62425;Communication, signalling and processing systems-Safety related electronics systems for Signalling and IEC:62427; Compatibility between rolling stock and train detection system.

4.2 The system shall be designed on fail safe principles. In case of any failure whether in the hardware, software or any part of the equipment,

the system and the equipments controlled by it should fail on the safe side and the system should change over to a more restrictive state.

4.3 No single failure shall result in an unsafe condition i.e. the system shall be brought to a safe state as soon as a failure occurs.

4.4 It must be ensured that if a failure of equipment occurs which by itself does not result in unsafe condition, but which in combination with a second or subsequent failure could result in an unsafe condition, then the design of the equipment must be such that the first failure is detected and negated. The probability of occurrence of a second failure, while the first failure has not been detected and negated, should be negligible.

4.5 The design of the equipment shall cater for detection and restoration of system to a safer state in case of following faults, if these are likely to result in unsafe condition:

(i) Variation in power supply beyond its tolerance limits including its momentary or prolonged failure;

(ii) Spikes in the power supply system, stray fields caused by traction vehicles or standby diesel generator sets;

(iii) Insertion of PCBs in wrong card slots;

(iv) Earthing of any component or wire or a combination of such earthing faults; and

(v) Broken wires, damaged or dirty contacts, failure of a component to energise, loss of power supply or blown fuses etc.

4.6 The equipment shall be so constructed as to prevent unauthorized access.

4.7 Whenever power of the equipment is switched on, the equipment should wait for a manual system reset before assuming normal operational mode unless otherwise as specified in relevant specification. This may or may not be applicable in Software embedded systems.

4.8 Manual reset switch, if provided, must have an non-resettable electro-mechanical counter which should be incremented every time a reset operation is performed. System reset switch must have a locking arrangement to prevent unauthorised operation.

4.9 All vital relays, including the safe shutdown relays, shall be of approved type for use in railway signalling.

5.0 HARDWARE

5.1 COMPONENT TYPES

5.1.1 ICs and other components used in the equipment shall be of such grade that these can work satisfactorily in -40^0 to $+85^0$ C temperature range. Capacitors used should be certified for at least +105 deg. C. Source of procurement of components shall be given in the Quality Assurance Plan.Discrete components like diodes, transistors, SCRs etc. should conform to HIREL program of CDIL or equivalent.

5.1.2 All resistors and rectifiers used shall be rated for at least double the power which is supposed to be dissipated in them. The voltage rating of the capacitor shall be at least 50% above peak value. The resistors and capacitors shall be of tolerances not more than 5%.

5.1.3 Where ICs are used, all power supplies on cards should be locally de-coupled using a capacitor with good high frequency characteristics. The value of chip decoupler ceramic capacitor shall be 0.1 to 1µF. The value of printed circuit board decoupler electrolytic capacitor shall be 10 to 100 µF and this capacitor should be placed near to the point where power supply enters PC board.

5.2 Connectors

Connectors used should generally conform to IEC: 60130.Connectors used should be chosen considering the following;

(i) Contact resistance,

(ii) Insulation between pins,

(iii) Ruggedness and resistance to vibration,

(iv) Resistance to entry of water or other contaminants,

(v) Resistance to pressure,

(vi) Reliability,

(vii) Lifetime (number of connect/disconnect operations before failure)

(viii) Ease of connecting and disconnecting.

(ix) They should be keyed to prevent insertion in the wrong orientation, connecting the wrong pins to each other, and have locking mechanisms to ensure that they are fully inserted and cannot work loose or fall out.

(x) Connectors that apply power should be designed such that certain pins make contact before others when inserted, and break first on disconnection to protects circuits.

(xi) Connector should be easy to identify visually, rapid to assemble, require only simple tooling.

(xii) Connectors used at radio frequencies must not change the impedance of the transmission line of which they are part. A radio-frequency connector must not allow external signals into the circuit, and must prevent leakage of energy out of the circuit. At UHF and above, silver-plating of connectors should be used to reduce losses.

5.3 DIAGNOSTIC FACILITY

5.3.1 In case of microprocessor based equipment, the system shall be provided with a front-panel alpha numeric LED/ LCD display unit indicating various failures. The error code should indicate type of the failure.

5.3.2 A trouble-shooting chart should be provided indicating the action required to be taken for repair of the equipment corresponding to each error code.

5.3.3 Audiovisual alarm shall be provided to indicate failure. The audio alarm should stop when acknowledged but the visual alarm should continue till the fault is rectified.

5.3.4 Equipment should have event logging facility along with networking capability to download the log from either local or a remote place. Equipment should have a port with suitable protocol to be interfaced with Datalogger equipment for diagnostic purposes.

5.4 HOUSING RACK

5.4.1 19 ″ rack mountable and 3/4/6U high cabinets made of aluminum of minimum thickness 2mm shall be used for housing the PCB cards. The cabinet shall be powder coated. The front & backsides of the cabinets shall have facility for completely locking the equipment. The rack should have provision for natural ventilation. If required, provision for forced cooling shall be made.

5.4.2 The equipment shall be housed in a rack with a transparent front panel, if required. The rack shall have provision for natural ventilation. Ventilation openings shall be louvers of less than 3mm size covered with wire mesh for protection against entry of rodents, lizards etc. The protection shall conform to IP-31 type protection as specified in specification NO. IEC:60034.

5.4.3 Rack shall be earthed as per the code of practice for earthing & bonding for signalling equipments, RDSO/SPN/197/2008.

5.4.4 The layout of the components and wiring shall be such that all parts are easily accessible for inspection, repairs and replacement.

5.4.5 The AC input portion shall be clearly isolated and protected to prevent accidental contact.

5.4.6 Dummy slots for inserting spare PCBs shall be provided if space is available in the rack.

6.0 PRINTED CIRCUIT BOARD

The PCB shall fulfil requirements of IEC-60255 and IEC 60352-5.

6.1 PCB MATERIAL: Material for the printed circuit board shall be copper clad glass epoxy of grade FR-4 or equivalent.

6.2 OUTLINE DIMENSIONS: PCB shall normally be of standard size (e.g.3/4/6U).

6.3 BOARD THICKNESS: The thickness of PCB cards and motherboard shall be as per currently available technology. There should be no deformity in the PCB cards or the motherboard due to mounting of heavy components or due to ageing effect.

6.4 TRACK WIDTH: The track width shall be 0.5 mm nominal. In no case it should be less than 0.3 mm. Lesser width for use of SMD technology may be considered.

6.5 SPACING BETWEEN TRACKS: Spacing between tracks shall be 0.5mm nominal and in no case it shall be less than 0.3 mm. Lesser spacing for use of SMD technology may be considered.

6.6 The printed circuit cards shall be specifically designed to suit the circuitry used and no extra wires or jumpers shall be used for interconnection of components on the PCB. No piggy-back PCB shall be connected to any PCB, unless otherwise specified. The components shall be soldered with wave-soldering machine. Any exception to wave-soldering machine shall have specific approval of RDSO, Lucknow.

6.7 The cards shall be provided with testing points and the corresponding voltages / waveforms shall be indicated in the fault diagnostic procedure and service manual to facilitate testing and fault tracing.

6.8 CONFORMAL COATINGS: Assembled & tested printed boards should be given a conformal coating to enable them for functioning under adverse environmental conditions. The coating material should be properly chosen to protect the assembly from the following hazards:

(a) Humidity;

(b) Dust and dirt;

(c) Airborne contaminants like smoke and chemical vapours;

(d) Conducting particles like metal clips and filings;

(e) Accidental short circuit by dropped tools, fasteners etc.;

(f) Abrasion damage and

(g) Vibration and shock (to a certain extent).

6.9 The solder masks shall be applied on the solder side and component side of the card.

6.10 Following description shall be etched/screen printed on the component side of the PCB:

(i) Component outline in the proximity of the component.

(ii) Manufacturer's name.

(iii) PCB name.

(iv) Equipment name.

(v) Part number.

6.11 Following description shall be engraved/etched/screen printed on the PCB

(i) The manufacturing serial number.

(ii) Month and year of manufacture.

(iii)Version number.

6.12 Printed circuit cards shall be fitted with gold plated Euro/ D type,CPU Type plug in connectors with locking arrangement. Mechanical arrangements e.g. a clip or a screw to hold the PCB in inserted position shall be provided. Screws should be countersunk and held on PCB when it is pulled out. The PCB shall be mechanically polarized so that it is not possible to insert the PCB into wrong slot.

6.13 HEAT DISSIPATING COMPONENTS: All components dissipating 3W or more power shall be mounted so that its body is not in contact with the board unless a clamp, heat sink or other means are used for proper heat dissipation.

6.14 The distribution of the power supply on the cards should be such that different voltage tracks (0, 5V etc.) follow the same route as far as possible. The track of power supplies should be as thick and wide as possible.

7.0 SOFTWARE REQUIREMENTS

Software should have been developed in conformity with a software engineering standard issued by recognized standards body such as CENELEC with special relevance to safety critical applications. The system should generally satisfy requirements of EN 50128: Railway applications- signaling and communication- Software for Railway control and protection system Particular software engineering standards used shall be specified and one complete set of such standards shall be made available to RDSO.

The software of system should generally have two layers:

(a) **Executive Software or System Software:** This Executive Software shall define what the system can do and how the various parts of the system operate together. It shall include all start up and operational safety tests (including checking the Executive Software itself) that are the parts of the processor for continual assurance of safety operation. The executive Software should have been independently verified and validated. As specified in the software Engineering Standards, full documentation on Quality Assurance Program specially the Verification and Validation (V&V) procedures carried out in-house or by any independent agency, should be made available to RDSO to check their conformity to the standards. If the procedure and documentation for V & V is considered inadequate, RDSO reserves the right to get the verification and validation of software and hardware done by an independent agency at the cost of the supplier.

(b) **Application Software:** It shall be containing the logic that defines how the inputs and outputs for a particular station are related. This shall be station specific. It shall not be possible to modify Executive Software. However, Application engineers should have the facility to modify application software as and when required. It should be possible to prevent unauthorized access for modifying the application software through a password protection.

The checksum of application software at the time of Factory Acceptance Test (FAT) matches with the checksum at the site (SAT) if there is no modification after FAT.

7.1 Software should be written in structured format. It should be developed in such a way that it is possible to test and validate each module independently.

7.2 The software shall be written in such a manner that in case of variable data, the possibility of using incorrect data does not exist. Further, the software should check and reject –

(a) Use of data which is obsolete or meant for some earlier state of the system, and

(b) Corruption of the data.

7.3 As far as possible, program flow should be independent of the input data. The program should preferably execute the same sequence of instructions in each cycle.

7.4 The use of interrupts should be kept to a bare minimum.

7.5 SELF CHECK PROCEDURES

Software should include self check procedures to detect faults in the hardware. The self check should include the following procedures:

(i) Memory containing the vital software and data should be checked periodically so that probability of corrupted software jeopardizing the safety of the equipment is minimized.

(ii) Components of the CPU, such as general purpose registers, program counters, stack pointers, instruction register, instruction decoder, ALU, etc., should be checked periodically as far as practicable.

7.6 Self check of the associated functional hardware as required by the hardware design should be performed periodically.

7.7 Critical and non-critical software should be segregated in the memory area so that special procedures to check the program flow may be adopted during the self check process for the critical software.

8.0 TRANSMISSION OF SIGNALLING INFORMATION

In the systems requiring transmission of vital safety, the following requirements shall be fulfilled in addition to the requirements of EN 50129 & IEC 62280;

8.1 It shall be possible to transmit the safety information over commercial voice channels / twisted pair copper cable/ OFC cables through use of proper multiplexers, unless other modes of transmission are specified by the purchaser.

8.2 The transmission protocol shall ensure required integrity of safety related information irrespective of transmission medium.

8.3 The overall system design must ensure that if the transmission link becomes inactive for more than a specified period, the safety information drain (user) will assume a restrictive and fail-safe state.

8.4 For systems relying on error prevention, all transmission equipment such as filters and amplifiers must be designated to meet specified fail safety standards.

8.5 Errors introduced or not detected at a given level in the transmission system must be detected at higher levels. Error detection methods used at any level must take into account the characteristics of the lower levels.

8.6 Error detection techniques should permit the use of standard telecommunication technology, which offers much more economic solutions than the special hardware needed to implement error prevention techniques.

8.7 Error detecting coding should not form the sole means of protection of transmitted information, but should be combined with other methods such as higher level procedures and protocols, and hardware redundancy or diversity.

8.8 Forward error correcting coding should not be used unless precautions are taken at the higher level to prevent invalid corrections from being accepted at the higher level.

9.0 ENVIRONMENTAL/ CLIMATIC REQUIREMENTS

9.1 The equipment shall be capable of working in non-air conditioned environment in the field.

9.2 The equipment shall be suitable for installation on AC/ DC electrified and non-electrified sections. It shall be suitable in all areas including where locomotives having thyristor controlled single phase or 3-phase induction motors haul passenger or freight trains and where chopper controlled EMU stocks are operated.

9.3 The equipment shall meet the following climatic and environmental requirements unless otherwise specified in the relevant specification and as per the IS or equivalent IEC standards:

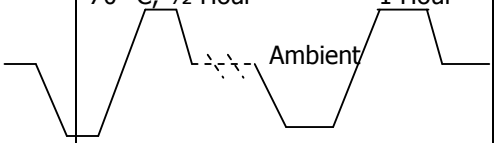
S. No	Test		Reference	Electronic Equipment				
				Indoor	Out-door		On board	
					On Track	Track side	Inside Cab	Outside Cab
1.	**Change of temp test**		IS 9000 Part XIV Sect. 2	Yes	Yes	Yes	Yes	Yes
	Low temp	-10^{o} C ± 3^{o} C						
	High temp	$+70^{o}$ C ± 2^{o} C						
	Rate of change in temperature	1^{o} C / min ± 0.2^{o} C						
	Duration	~~≠~~ 3 hrs at each temp. – 10 ^{o} C & +70 ^{o} C						
	Cycle	2 (or as otherwise specified)						
	Condition	Fully functional during test						
2.	**Dry heat test**		IS:9000 Part-III Sect 3	Yes	Yes	Yes	Yes	Yes
	Temp	$+70^{o}$C ± 2^{o} C (The rate of change of Temp shall not exceed 1^{o} C per min averaged over 5 min.)						
	Duration	16 hrs						
	Condition	Fully functional during test						
3.	**Cold test**		IS 9000 Part II Sect. 3	Yes	Yes	Yes	Yes	Yes
	Temp	-10^{o} C ± 3 ^{o} C (The rate of change of Temp shall not exceed 1^{o} C per min averaged over 5 min.)						
	Duration	2 hours						
	Condition	Fully functional during test.						
4.	**Damp heat test (Cyclic)**		IS 9000 Part V Sect. 2 12+12 h cycle Variant 1	Yes	Yes	Yes	Yes	Yes
	Upper temp	40^{o} C ± 2 ^{o} C						
	Humidity	95% (+1%, -5%)						
	Cycles	6						

	Condition	Fully functional during one hour period towards end of any intermediate cycles and last cycle. Stabilization shall be done at 25° ± 3 °C						
5.	**Damp heat test (Steady state)**		IS 9000 Part IV	Yes	Yes	Yes	Yes	Yes
	Temp	40° ± 2 °C						
	Humidity	93% (+2%, -3%)						
	Severity	4 days						
	Condition	Fully functional during test.						
6.	**Salt mist test**		IS 9000 Part XI procedure 3/2	Yes Procedure 3	Yes Procedure 2	Yes Procedure 2	Yes Procedure 3	Yes Procedure 2
	Mist + Damp heat	Procedure 2: 2 hours + 7 days Procedure 3: 2 hours + 22 hours						
	Temp	35° ± 3 °C						
	Humidity	93% (+2%, -3%)						
	Cycle	Procedure 3:3 Procedure 2:4						
	Condition	After this test, electrical parameters shall be monitored in addition to physical checks.						
7.	**Dust test**		IS 9000 Part XII	Yes	Yes	Yes	Yes	Yes
	Duration	1hour						
	Temp	40° ± 3 °C						
	Condition	After this test, electrical parameters shall be monitored in addition to physical checks.						
8.	**Water Immersion test**		IS 9000 Part XV Sect. 7	No	Yes	~~No~~ Yes	No	~~No~~ Yes
	Head of water	0.4 m						
	Duration	24 hours						
	Condition	After this test, electrical parameters shall be monitored in addition to physical checks (Ingress of water).						

9	**Driving Rain test** Water spray for 1 hour Condition: After this test, electrical parameters shall be monitored in addition to physical checks.		IS 9000 Part XVI Test condition 'C'	No	Yes	Yes	No	Yes
10	**Bump test** PCBs/Modules/units in packed condition shall be subjected to bump test as under: No of bumps: Case 1: 1000 ± 10, Case 2: 4000 ± 10 Peak acceleration: 40g Pulse duration: 6 ms No of axes: 3 Condition: After this test, electrical parameters shall be monitored in addition to physical checks.		IS 9000 Part VII, Sec. 2	Yes case 1	Yes case 2	Yes case 1	Yes case 2	Yes case 2
11	**Shock test (to simulate the effect of shunting shock)** The equipment in operation shall be subjected to 3 successive shocks in each direction of three mutually perpendicular axes of the specimen, (18 shocks) = of such nature that the maximum acceleration is equal to 300 m/s^2 .The corresponding duration of the nominal pulse shall be 18 ms. At the end of the test, the assembly shall be subjected to performance test as specified in relevant specification.		IS 9000 Part VII Sec. 1	No	Yes	Yes	Yes	Yes
12	**Vibration test**		TEC (IPT 1001A-revised) or IS 9000 Part VIII as specified	Yes	Yes	Yes	Yes	Yes
		Up to & including 75 Kgs. weight	**Over 75 Kgs.**					
	Freq. Range	05-350 Hz	5-150 Hz					

	Amplitude	± 6 mm constant displacement or 15m/ Sec.^{2} constant acceleration	± 6 mm constant displacement or 15m/ Sec.^{2} constant acceleration						
	No. of axes	3	3						
	No of sweep cycle	20	10						
	Total duration	105 min	105 min						
	If resonance is observed	10 min at each resonant freq.	10 min at each resonant freq.						
	Condition	After this test, electrical parameters shall be monitored in addition to physical checks.							

S. No	**Test**	**Reference**	**Electronic Equipment**				
			Indoor	**Out-door**		**On board**	
				On Track	**Track side**	**Inside Cab**	**Outside Cab**
13.	**Environmental Stress Screening tests (ESS) for Printed Circuit Boards (PCB) & sub systems** *(The manufacturer shall carry out the following ESS tests on all modules on 100% basis (except bump test) during production / testing in the sequence as follows. Suitable records shall be maintained regarding the compliance of these tests.)*		Yes	Yes	Yes	Yes	Yes

13.1	**Thermal cycling** The PCBs shall be subjected to thermal cycling as per the procedure given below. The assembled boards are to be subjected to rapid temperature cycling as mentioned below in the power off condition.		Yes	Yes	Yes	Yes	Yes
	❖ This temperature cycling from 0° C to 70^0C, ½ Hours at each temperature for 9 cycles and 1 hour at each temp. for the 10^{th} cycle. Dwell time of 1 hour is provided for the last cycle in order to oxidize defective solder joints exposed through thermal stress.						
	70° C, ½ Hour 1 Hour  0° C, ½ Hour r ❖ The rate of rise / fall of temp. shall be minimum 10° C per minute. ❖ In addition to physical checks, the electrical parameters are also to be monitored after this test.						
13.2	Power cycling: The power supply modules shall be subjected to 60 ON-OFF cycles for 1 hour. The ON-OFF switch usually provided in the modules may not be used for this purpose.		Yes	Yes	Yes	Yes	Yes

9.4 Electromagnetic Interference and Electro Magnetic Compatibility

9.4.1 All equipments shall comply with IEC: 62236. To protect against the electromagnetic interference, the following should be ensured;

(i) Shielding at card level by providing a metallic plate over the cards. The Metallic plate shall be earthed.

(ii) Shielding at chassis/ rack level.

(iii) Circuit design for minimum radiation: Any cable will receive and radiate signals, especially when it approaches a quarter wavelength, or odd multiple thereof because it forms a resonant circuit. However

even when the cable does approach these lengths, electromagnetic compatibility, EMC can be a problem.

(iv) EMC filters: EMC filters should be used for lines that carry low frequency signals like Power input cables, or other lines that carry status voltages to remove any high frequency components, leaving the low frequency elements on the line that will not radiate much. EMC filters should be placed at the entry point to the unit, and should be tightly bonded to the chassis so that no signals can enter the unit and radiate into it prior to being removed by the filter.

(v) Circuit partitioning: The circuit should be segregated into EMC critical and non-critical areas. The critical or sensitive regions should be screened or and filters added as necessary at the interfaces to prevent EMI being radiated, or to protect these circuits from the effects of EMI.

(vi) Grounding: Thick wires should be used if possible, and on printed circuit boards ground planes must be used. Critical tracks must be run above the ground plane, and they should be routed so that they do not encounter any breaks in the ground plane. Sometimes it is necessary to have a slot or break in a ground plane, and if this occurs a critical track must be routed over the plane, even if it makes it slightly longer.

(vii) Screened Enclosure: Placing the unit in a conductive enclosure that is grounded will significantly improve the performance. Where cost and possibly aesthetics are important it is possible to spray the inside of cabinets with conductive paint, although the level of screening provided will not be nearly as good as if a fully conductive metal case is used. Where high levels of EMC performance are required care should be taken to choose a case where the continuity of the screen is not breached. The case should ideally be made of as few elements as possible. At each joint there will be the possibility of radiation passing through. Where joints to occur they should be as tight as possible and they should have good continuity between them.

(viii) Screened lines and cables: When lines and cables need to pass into or out of a unit, the cables can be screened to prevent any radiation of the signals being carried or pick up of external signals. However when screened cables are needed for electromagnetic compatibility EMC applications, the screen must be bonded to the equipment signal ground as soon as it enters the unit, otherwise unwanted signals may be radiated or picked up and this would compromise the EMC compliance.

9.4.2 EMI EMC test stages

In order that a product may pass its EMC compliance, the EMC testing should be undertaken at various stages of the life of the product enlisted as under.

- Development test
- Pre-compliance test
- EMC compliance test
- Production test

9.4.3 EMC test types

Following testing for EMI/EMC generally need to be conducted.

- Conducted emissions
- Radiated emissions
- Conducted immunity
- Radiated immunity
- ESD immunity
- Transient immunity
- Surge immunity

9.4.4 The system operation and its safety should not be affected by EMI/EMC issues for which the following tests should be conducted on the equipment and as specified in the relevant specification of the equipment

EMI encountered in 25 KV AC electrified areas.
For those outdoor equipment which are used in 25 KV AC electrified areas and whose working is susceptible to the effect of electrostatic and electromagnetic induction, the following tests 9.4.4.1 and 9.4.4.2 may be performed as given in relevant specification.

9.4.4.1 One sample of the test equipment shall be subjected to static discharge test as per IEC 61000-4-2. 8KV test voltage is to be taken, unless otherwise specified in the relevant specification. Methodology of test is given below:

a) The equipment shall be functional and the chassis of the equipment shall be firmly grounded.

b) A charged capacitor of ∓ 8 KV should be discharged by touching the chassis by testing probe through 330Ω resistance and 150 pF capacitor.

c) The above discharge test should be repeated minimum 3 times.

d) After completion of the test, the equipment shall be able to continue its normal operation.

e) If given in the relevant specification, the discharge test should be carried out on individual card/ module also.

9.4.4.2 Pantograph Interference Test: One prototype of the equipment shall be installed in the actual field condition in AC electrified traction area. An AC electric loco shall be placed in a position on the track such that distance between nearest face of the equipment and point of catenary where pantograph is touching, is about 4.0 meters.

The equipment shall be tested for its normal working during raising and lowering of the pantograph. This test will be repeated for sufficient number of times. The equipment will be tested for its normal operation after completion of the test.

9.4.4.3 Test according to IEC 61000-4-2 *(Electrostatic discharge immunity test)*

In general, the electrostatic discharge test is applicable to all equipment which is used in an environment where electrostatic discharges may occur. Direct and indirect discharges shall be considered.

9.4.4.4 Test according to IEC 61000-4-3 *(Radiated, radio-frequency, electromagnetic field immunity test)*

In general, the radiated immunity test is applicable to all products, where radio-frequency fields are present.

9.4.4.5 Test according to IEC 61000-4-4 *(Electrical fast transient/burst immunity test)*

In general, the fast transient test is applicable to products which are connected to mains or have cables (signal or control) in close proximity to mains.

9.4.4.6 Test according to IEC 61000-4-5 *(Surge immunity test)*

The surge test is applicable to products which are connected to networks leaving the building or mains in general.

9.4.4.7 Test according to IEC 61000-4-6 *(Immunity test to conducted disturbances induced by radio-frequency fields)*

In general, the conducted immunity test is applicable to products, where radio-frequency fields are present and which are connected to mains or other networks (signal or control lines).

9.4.4.8 Test according to IEC 61000-4-7 *(General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto)*
This technical report defines the measurement method of harmonics and interharmonics

9.4.4.9 Test according to IEC 61000-4-9 *(Pulse magnetic field immunity test)*
This test is mainly applicable to products to be installed in electrical plants (for example Tele control centres in close proximity to switchgear).

9.4.4.10 Test according to IEC 61000-4-10 *(Damped oscillatory magnetic field immunity test)*
This test is mainly applicable to products to be installed in high-voltage substations.

9.4.4.11 Test according to IEC 61000-4-11 *(Voltage dips, short interruptions and voltage variations immunity test)*
This document defines the test methods to evaluate the immunity of an equipment connected to the LV system, to voltage dips, short interruptions and voltage variations. This test is applicable to equipment with a rated input current of less than 16 A per phase, connected to a.c. mains.

9.4.4.12 Test according to IEC 61000-4-14 *(Voltage fluctuation immunity test)*
In general, voltage fluctuations have an amplitude not exceeding 10 %; therefore, most equipment is not disturbed by voltage fluctuations. However, this test may be applicable to equipment intended to be installed at locations where the mains have larger fluctuations.

9.4.4.13 Test according to IEC 61000-4-17 *(Ripple on d.c. input power port immunity test)*
This test applies to equipment connected to d.c. distribution systems with external batteries charged during the operation of the equipment.

9.4.4.14 Test according to IEC 61000-4-28 *(Variation of power frequency, immunity test)*
In general, the test for variation of the power frequency is not applicable. However, it may apply to equipment intended to be installed at locations where the power frequency has large variations (for example equipment connected to an emergency power supply).

9.4.4.15 Test according to IEC 61000-4-29 *(Voltage dips, interruptions and voltage variations on d.c. input power ports, immunity tests)*

In general, this test is applicable for d.c. input power ports.

9.4.4.16Test according to IEC 61000-4-30 *(Measurements of power quality parameters)*

This standard gives clarification on the measurement of power quality parameters.

9.5 Insulation Resistance Test: This test shall be carried out –

(a) Before the high voltage test
(b) After the high voltage test
(c) After completion of the climatic test

There shall be no appreciable change (value more than 10 Mega ohms and variation within 10%) in the values measured before and after high voltage test. After the completion of climatic test, the values shall not be less than 10 Mega ohms for the equipment at a temperature of 40^0 C and relative humidity 60%. The measurement shall be made at a potential of 500V DC.

9.6 Applied High Voltage Test: The equipment shall withstand for one minute without puncture and arcing a test voltage of 2000 volts rms applied between:

(a) AC line terminals and earth
(b) DC line terminals and earth

The test voltage shall be alternating of approximately sinusoidal wave form of any frequency between 50 Hz. and 100 Hz. Printed circuit cards shall be removed.

9.7 Hermetic Sealing Test

The equipment/component is to be subjected to Dust Test and Driving Rain Test as per para 9.3(7) and 9.3(9) of this specification. After the tests the equipment should not show traces of water vapour or water inside the seal, if visible and should electrically function/operate within limits. In cases where the sealed equipment/component is opaque, electrically the equipment/component should function/operate within limits.

10.0 POWER SUPPLY REQUIREMENTS

10.1 The equipment shall work on nominal voltage 24V DC (+20%, -30%) power supply or as specified in the relevant equipment specification or as approved by the purchaser.

10.2 Where separate DC-DC converters are used to derive the required DC voltages from the DC main input, these should conform to IRS: S-96 for DC-DC converters.

10.3 If the equipment has a separate Battery Charger, the battery shall be used in float charge mode from the AC mains at 230V. The battery charger shall be of low ripple voltage output type as specified in IRS: S-86 for axle counter.

10.4 A line surge suppresser (MOVRs) on input side shall be provided in the battery charger to protect against transient voltages spikes etc. For chargers meant for Telecom/Axle Counter/EI applications, RFI, EMI filters shall also be provided both on input & output sides.

11.0 LIGHTNING AND SURGE PROTECTION FOR ELECTRONIC SIGNALLING EQUIPMENTS

11.1 The equipment shall be suitably protected against atmospheric voltage surges both for common mode (voltage that appears between phase conductors and earth) and differential mode (voltage that appears between neutral & earth) in order to limit the harmful effects of lightning.

11.2 The IEC standards 61643, 62305 pertaining to protection against lightning and surges shall apply for all electronic equipment to withstand static electricity, electric fast transient and surge voltage.
The power line of electronic signalling equipment shall have Class B & C type 2-stage protection in TT configuration. Stage 3 protection is also required for protection of power/signalling/data lines. Class B & class C type protection devices shall preferably be pluggable type to facilitate easy replacement.

11.3 **Stage 1 Protection (Power line protection at Distribution Level)**

(a) The Stage 1 protection shall consist of coordinated Class I/ B & II/ C type SPDs at the entry point of input 230V AC supply in Power /Equipment room in TT configuration in a separate wall mountable box. The Class I/B SPD shall be provided between Line to Neutral & Neutral to Earth. They shall be spark gap type voltage switching device and tested as per IEC 61643 with the following characteristics and features-

SN	Parameters	Limits	
		Line & Neutral	Neutral & Earth
1	Nominal Voltage (U_0)	230V	230V
2	Maximum continuous operating voltage (U_c)	≥ 255V	≥ 255V
3	Lightning Impulse current (I_{mp}) 10/350µs for each phase	≥ 25 KA,	≥ 50KA
4	Response time (T_r)	≤ 100 ñs	≤ 100 ñs
5	Voltage protection level (U_p)	≤ 2.5 KV	≤ 2.5 KV
6	Short circuit withstand and follow up current extinguishing capacity without back up fuse (I_{sc})	≥ 3 KA	≥ 100 A

7	Operating temperature / RH	-25^{O} C – 80^{O} C / 95%	-25^{O} C – 80^{O} C /95%
8	Mounted on	din rail	din rail

(b) The Class I/ B SPD will be followed by Class II/ C SPD adjacent to it and connected between Line & Neutral. The device shall be a single compact varistor of proper rating and in no case a number of varistors shall be provided in parallel. It shall be voltage clamping device, thermal disconnecting type and shall be tested as per IEC 61643 with the following characteristics and features-

SN	Parameters	Limits
1	Nominal Voltage (U_0)	230V
2	Maximum continuous operating voltage (U_c)	≥ 300V
3	Nominal discharge current between R,Y,B & N (I_n)	≥ 10KA, 8/20μs for each phase
4	Maximum discharge current between L & N (I_{max})	≥ 40KA, 8/20μs
5	Response time (T_r)	≤ 25 ñs
6	Voltage protection level (U_p) at I_n	≤ 1.5 KV
7	Operating temperature / RH	-25^{O} C – 80^{O} C / 95%
8	Mounted on	din rail

(c) Class I/B and class II/C SPDs of Stage I shall be so coordinated that the voltage protection level of the coordinated devices is ≤ 1.5 KV. As such, these devices shall be from the same manufacturer and necessary test certificate in this regard shall be submitted by the manufacturer/ supplier.

11.4 Stage 2 protection (at the output side inside the distribution panel)

The Stage 2 protection shall consist of Class II/ C type SPDs for ≥24V-110V AC/DC supplies at the output side inside the rack of equipment. These shall be provided for External circuits The Class II/C type SPD shall be a single compact varistor of proper rating and in no case a number of varistors shall be provided in parallel. It shall be voltage clamping device and thermal disconnecting type. They shall be tested as per IEC 61643 with the following characteristics and features-

SN	Parameters	Limits (between L1 & L2, L1 & E , L2 & E)	
1	Nominal Voltage (U0)	60V-110V AC/DC	24V-60V AC/DC
2	Maximum continuous operating voltage (Uc)	≥150 (AC) ≥200 (DC)	≥75 (AC) ≥100 (DC)
3	Nominal discharge current 8/20ms (In)	≥ 10KA	≥ 10KA
4	Maximum discharge	≥ 40KA	≥ 40KA

	current 8/20ms (Imax)		
5	Response time (Tr)	≤ 25 ñs	≤ 25 ñs
6	Voltage protection level(Up)	≤1.0 KV	≤ 0.5 KV
7	Operating temperature /RH	-25^{O} C – 80^{O} C / 95%	-25^{O} C – 80^{O} C / 95%
8	Mounted on	Din rail	Din rail

11.5 **Stage 3 protection (Protection for Power /signalling / data lines)**

All external Power/signalling/data lines (AC/DC) shall be protected by using preferably pluggable stage 3 surge protection devices which consists of a combination of varistors/suppressor diodes and GD tube with voltage and current limiting facilities.

11.5.1 **Power line Protection (Class D)**

The device for power line protection shall be of Class D type. This shall have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. This shall be thermal disconnecting type and equipped with potential free contact for remote monitoring. This protection shall be in compliance to IEC 61643 with following characteristics:

Nominal Voltage (U_0)	24V	48V	60V	110V	230V
Max. continuous operating voltage (U_C)	30V	60V	75V	150V	253V
Rated load current (I_L)	16A	16A	16A	16A	16A
Nominal discharge current (I_n) 8/20 μs	≥700A	≥700A	≥700A	≥2.0KA	≥2.5KA
Max discharge current (I_{max}) 8/20 μs	≥2KA	≥2KA	≥2KA	≥5KA	≥5KA
Voltage protection level (U_P)	≤200V	≤350V	≤500V	≤700V	≤1100V
Response time (T_r)	≤25 ñs	≤25 ñs	≤25 ñs	≤25 ñs	≤25 ñs

Note: Minor variations from above given parameters shall be acceptable.

11.5.2 **Signalling/Data line protection**

These devices shall preferably have an indication function to indicate the prospective life and failure mode to facilitate the replacement of failed SPDs. If the device has any component which comes in series with data/ signalling lines, the module shall have "make before break" feature so that taking out of pluggable module does not disconnect the line. This protection shall be in compliance to IEC 61643 with the following characteristics:

Nominal Voltage(U_0)	5V	12V	24V	48V
Arrester Rated Voltage(U_C)	6V	13V	28V	50V
Rated load current(I_L)	≥250mA	≥250mA	≥250mA	≥250mA
Total discharge current, 8/20 μs (I_n)	≥20KA	≥20KA	≥20KA	≥20KA
Lightning test current 10/350 μs	≥2.5KA	≥2.5KA	≥2.5KA	≥2.5KA
Voltage protection level (U_P)	≤10V	≤18V	≤30V	≤70V

Note: Minor variations from above given parameters shall be acceptable.

11.5.3 If power supply /data / signalling lines (AC/DC) are carried through overhead wires or cables above ground to any nearby building or any location outside the equipment room, additional protection of Stage 2 (Class C) type shall be used at such locations for power supply lines and Stage 3 protection for signal / data lines.

11.6 Coordinated type Class B & C arrestor shall be provided in a separate enclosure adjacent to each other. This enclosure should be wall-mounting type.

11.7 Length of all cable connection from input supply and earth busbar to SPDs shall be minimum possible. This shall be ensured at installation time.

11.8 Stage 1 & Stage 2 (Class B & C) protection should be from the same manufacturer/supplier. Manufacturer shall provide Stage 1 & Stage 2 protection. Stage 3 protection shall be got provided by Railways separately.

11.9 The cross sectional area of the copper conductor for first stage protection shall not be <16 mm^2 and for second stage shall not be < 10mm^2

11.10 Batch test report of OEM should be submitted by the manufacturer /supplier of Lightning & Surge protection devices to the IPS manufacturer at the time of supply of these devices. Copy of the same shall be submitted by manufacturer to RDSO at the time of acceptance test of equipment.

12.0 MARKING

All indigenous equipments shall meet the following requirement;

12.1 All markings/ indications shall be easily legible and durable. Where the marking is by use of labels, the labels shall be metallic and shall be firmly fixed and shall not be capable of being removed by hand. Durability of marking shall be checked by rubbing the marking by hand with a piece of cloth soaked with petroleum spirit. This requirement shall also be met after completion of climatic test.

12.2 All markings/ indications shall be placed in the vicinity of the components to which these refer and shall not be placed on removable parts, if these parts can be replaced in such a way that the marking / indications can become misleading.

12.3 The words 'Indian Railway Property' shall be etched, engraved, screen printed or embossed on the equipment at a conspicuous position. For it, the size of the letters shall be chosen depending upon the equipment but shall not be less than 20mm high in any case.

12.4 The following information shall be engraved on the anodized name plate firmly attached to the equipment.

(a) Name or trademark of the manufacturer.
(b) Specification number.
(c) Serial number of the equipment.
(d) Installation for which meant.
(e) Month and year of manufacture.
(f) Version number.
(g) Equipment Name

13.0 DOCUMENTATION

Two copies of the following manuals shall be supplied:

13.1 System description manual and Instruction Manual

13.2 Installation and Maintenance Manual including Dos & Don'ts.

13.3 Mechanical drawings of each sub-system/ rack.

13.4 Guaranteed performance data, technical & other particulars of the equipment.

13.5 Schematic block diagram showing mounting arrangement of various components & details of each type of assembled PCB.

13.6 Trouble shooting procedures along with test voltages and waveforms at various test points in the PCBs. The possible error codes and thereafter actions required should be mentioned in the maintenance manual.

13.7 Details of software viz. Source code, algorithm, flow chart, machine code along with test/ validation procedure used and the results thereof.

13.8 Details of Hardware e.g. schematic diagrams of the system circuits/ components, details for each type of assembled PCB and part-list.

13.9 Pre-commissioning check list.

14.0 PACKING

14.1 The equipment and its sub assemblies shall be wrapped in bubble sheet and then packed in thermo Cole boxes and the empty spaces shall be filled with suitable filling material. All PCBs shall be enclosed in anti-static shield cover. The equipment shall be finally packed in a wooden case of sufficient strength so that it can withstand bumps and jerks encountered in a road/ rail journey.

14.2 Each box shall be marked with code numbers, contents and name of manufacturer. The upside shall be indicated with an arrow. Boxes should have standard signages to indicate the correct position and precaution "Handle with Care" with necessary instructions.

14.3 Printed circuit boards shall be separately and individually packed to prevent damage.

****

Annexure I

List of Abbreviations

SN	Abbreviation	Full Form
1	AC	Alternating Current
2	AFTC	Audio Frequency Track Circuit
3	ALU	Arithmetic Logic Unit
4	CDIL	Continental Device India Limited
5	CENELAC	European Committee for Electro technical Standardization
6	CPU	Central Processing Unit
7	DC	Direct Current
8	ESD	Electrostatic Discharge
9	EMU	Electrical Multiple Unit
10	EMI	Electromagnetic Interference
11	EMC	Electromagnetic Compatibility
12	EPROM	Electrically Programmable Read Only Memory
13	FAT	Factory Acceptance Test
14	GD	Gas Discharge
15	HIREL	High Reliability
16	IC	Integrated Chip
17	IEC	International Electrotechnical Commission
18	IP	Internet Protocol
19	IPS	Integrated Power Supply
20	IRS	Indian Railway Standards
21	IS	Indian Standards
22	ISO	International Organization for Standardization
23	LCD	Liquid Crystal Display
24	LED	Light Emitting Diode
25	MTBF	Mean Time Between Failure
26	MTBWSF	Mean Time Between Wrong Side Failure
27	OEM	Original Equipment Manufacturer
28	OFC	Optical Fibre Communication
29	PCB	Printed Circuit Board
30	RDSO	Research Design and Standards Organisation
31	RFI	Radio Frequency Interference
32	PROM	Programmable Read Only Memory
33	QA	Quality Assurance
34	SAT	Site Acceptance Test
35	S&T	Signalling and Telecommunication
36	SCR	Silicon Controlled Rectifier
37	SMD	Surface Mount Technology
38	SPD	Surge Protection Device
39	SSI	Solid State Interlocking
40	UHF	Ultra High Frequency
41	V&V	Verification and Validation